Technical Notes in Response to Party Comments

on RPS Calculator - Version 6.0

February 9, 2015

Background

The October 10, 2014 ruling by the Administrative Law Judge in R.11-05-005 entered into the record a proposal by Energy Division staff regarding an update to the RPS Calculator (version 6.0). This document provides responses to certain comments and questions concerning the RPS Calculator submitted by parties in response to the ruling. It also provides a more detailed technical explanation of calculator mechanics than is available in the User Guidebook. This document is being provided as an additional resource for parties to review prior to attending the RPS Calculator Workshop on February 10-11, 2015..

Resource Cost & Potential

1. **How does the CPUC intend to address DRECP (and the results of other potential future land use planning exercises) in the RPS Calculator?**

Currently, the environmental exclusions used to discount the available resources are for stakeholder vetted areas where development is prohibited or practically impossible. The environmental exclusions were implemented in a manner to ensure that the Calculator did not prejudge permitting or identify preferred development locations. In practice, this led to a merging of stakeholder vetted public datasets from RETI, the WECC Environmental Data Task Force, and the Feinstein California Desert Protection Act. Specific information and references for the exclusions that have been applied can be seen in the "Resource Exclusions" section of the file "RPS_CalcV6.0_ResourcePotentialandCost.pptx" posted on the CPUC's RPS Calculator website.

The specific locations identified as preferred development areas (DFAs) in the DRECP study have not been prioritized into the Calculator because the analysis is not final and because development in other locations within the DRECP study area is permitted. Limiting development locations within the DRECP to only DFAs would create a bias which would be inconsistent with the approach taken for the rest of the state.

Final input from state agencies and stakeholders on how to apply the DRECP study will guide how these areas are treated in the Calculator. If the areas within the DRECP outside of DFAs are prohibited from development, they will be excluded. In addition, future work on environmental scoring will use DRECP recommendations to help rank projects and/or Super CREZs.

2. **What is the intended definition of a "Super CREZ"?**

CREZs as defined by RETI identified the best resources for large scale transmission development considering technical, economic and environmental factors. These had very specific boundaries and were purposefully made as small as possible to minimize environmental footprint. The "Super CREZs" as defined by this analysis are intended to capture most of the resources in California regardless of relative economic or environmental considerations. The intent is not for siting or environmental assessment, but rather for categorization and assigning transmission upgrade costs. This was necessary due to the vast increase in the economic development area for solar PV.

Note that while the full Super CREZ location appears on the map, this does NOT mean that the full region is acceptable for development anywhere within the Super CREZ. The resources in the supply curve already reflect the environmental and other exclusions which do not appear within the Super CREZ boundary definition. Future work that will be performed during Track 2B will consider options for reintroducing environmental scoring into the Calculator for projects and/or Super CREZs. When finalized, this would allow a broader comparison of development areas on a range of criteria, similar to what was performed in RETI.

Staff consulted with the CAISO and the CAISO agreed that the new Super CREZ approach results in some loss of transmission granularity, i.e., may obscure smaller transmission constraints within a given Super CREZ. Follow-up on this issue will be addressed in a wider discussion regarding process development for formal and periodic updates to the RPS Calculator.

3. **What environmental exclusions are reflected in the assessment of renewable resource potential within each Super CREZ?**

See answers to questions 1 and 2 above for information on the main exclusions and how these exclusions are applied when estimating the level of resource availability within each Super CREZ. Besides the environmental exclusions listed above, military land (with some exceptions), tribal lands, active mines, airports, urban land, and bodies of water were also excluded. Some technologies had resource specific exclusions applied, such as keeping wind projects out of military flight paths.

4. **How will resource cost & performance assumptions for the RPS Calculator be refreshed?**

Following the Feb 10th and 11th workshop, Black & Veatch will perform a cost update for all resources in v.6.1 of the RPS Calculator later in 2015. Going forward, it is expected that the commission will establish a formal and regular process for updating the RPS calculator inputs, assumptions, and the methodology. A proposal will be circulated after the workshop for stakeholder comment.

5. **What references were used in estimating cost and performance data?**

See the document "RPS_CalcV6.0_ResourcePotentialandCost.pptx" posted on the CPUC's RPS Calculator website for a detailed discussion of the cost and performance approach used in updating these inputs in the RPS Calculator. When possible, previously-vetted information from RETI, WREZ, SB1122 Analysis, and the NREL Renewable Electricity Futures reports were used (each of these reports has a full explanation of the data sources used). Internal Black & Veatch data based on work performed on design and construction projects, financial due diligence, bid reviews, and market modeling were also used when developing costs for most technologies.

Levelized Cost of Energy

6. **What assumptions regarding the expiration of the PTC have been made in calculating resource LCOEs?**

Over the course of the past decade, the federal production tax credit (PTC) has expired and been renewed on numerous occasions, leading to a “boom-and-bust” cycle of wind power development. The PTC most recently expired on December 31, 2014, but there remains a high degree uncertainty going forward regarding its renewal. The impact of the PTC on PPA prices is further complicated by the fact that currently a project must begin construction, rather than enter into operations, by the sunset date; the RPS Calculator does not monitor construction periods. Because of these factors, the RPS Calculator currently relies on a simplifying assumption that applies the PTC to all projects that come online before then end of 2016, which is consistent with the expiration of the federal investment tax credit (ITC).

7. **What assumptions regarding the expiration of the solar property tax exemption are made in the RPS Calculator?**

The RPS Calculator v.6.0 assumes that the solar property tax exemption expires at the end of 2016, which was the current statute at the time of the model’s development. This exemption has since been extended through 2024; this change in policy will be reflected in v.6.1 of the RPS Calculator.

8. **What is the basis for using cost-based PPAs instead of market-based pricing in the Calculator?**

In the RPS Calculator, cost-based PPA prices are calculated for each resource such that the project’s cash flow would be sufficient to provide a necessary return of and on capital needed by the developer. CPUC recognizes that these figures may not align perfectly with the market-based PPAs, which may be higher or lower for a variety of reasons. However, the Calculator’s primary function is to develop a plausible RPS portfolio. The use of cost-based PPAs (both for new and recontracting projects) in resource selection reflects an assumption of rational action on the part of developers/plant owners, who would not be expected to mark up bids above cost at the expense of their selection in a competitive solicitation. This methodology also alleviates the need to use market-sensitive information from actual PPAs.

9. **Why are recontracted resources replaced in the supply curve assuming a capital cost of 25% of the cost of a new plant?**

In order to continue operating, resources with expiring contracts may require major reinvestments, such as a new boiler at a geothermal facility or new turbines at a wind plant. However, the level of reinvestment needed for recontracting is highly uncertain and very project-specific and there is a lack of publically available cost data that could be applied to expiring resources in the RPS Calculator. In the absence of project-specific data, a capital cost multiplier of 25% is used as a proxy for the cost of extending the lifetime of existing resources, which allows the RPS Calculator to explicitly compare the value of retiring resources against new renewable resources.

Transmission

10. **How are upgrade costs developed for in-state Deliverability Network Upgrades (DNUs) and out-of-state transmission lines?**

In-state DNU: For a subset of Super CREZs, the CAISO provides estimates of the capital costs associated with specific potential DNU projects (which may represent minor or major upgrades in the RPS Calculator). The CAISO relies on a number of sources of information in developing these cost estimates, including Interconnection (IC) studies and Transmission Planning Process (TPP) policy driven studies and the unit cost estimates of Participating Transmission Operators (PTOs). Cost updates for these projects are generated by the CAISO based on updated study and unit cost information.

In areas where CAISO does not provide cost information for major upgrades, the RPS Calculator relies on estimations of the cost of conceptual new transmission projects (i.e. a new high voltage right-of-way) developed based on assumed unit costs of transmission. The estimated costs of conceptual lines were originally developed for RPS Calculator v.2.0-5.0, but Black & Veatch will update these cost estimates in v.6.1 based on the latest PTO unit cost estimates.

Out-of-state transmission**:** Previous work for the 2013 WREZ model and RETI 2B conducted by Black & Veatch is the primary source for out-of-state costs. These costs are escalated during each RPS Calculator update to present year dollars.

11. How are Interconnection (IC) upgrade costs captured in the RPS Calculator?

Interconnection costs are estimated by Black & Veatch using unit cost estimates provided by PTOs to the CAISO through an annual CAISO stakeholder process. Gen tie length and interconnection equipment requirements are developed for projects based on the location of the generator in proximity to existing transmission circuits or substation facilities. PTO unit costs are used to calculate the total cost of designated interconnection upgrades. Individual PTO unit costs are applied based on the PTO territory of a project interconnection.

In RPS Calculator v.6.0, these interconnection costs are included in the capital cost of the renewable generation project. In v.6.1, these costs will be broken out as an independent component of cost.

12. How is the CAISO's transmission access charge (TAC) treated in the model?

The TAC is not included in the resource ranking and selection logic (which considers only the incremental cost of new transmission associated with renewable projects), consequently, the TAC has no impact on the resources that are selected. However, the Calculator does use the TAC in the calculation of cost impacts, which measures the total revenue requirement for each utility. The cost calculation assumes that the cost of new transmission investments needed to deliver renewables will be included in the TAC and thus recovered through ratepayers.

13. How are the costs of delivery network upgrades allocated to prospective resources in the resource ranking and selection algorithm?

In each Super CREZ, the transmission "supply curve" is organized into three tiers: (1) existing transmission; (2) minor upgrades; and (3) major upgrades. Resources in each Super CREZ compete for available transmission capacity in each tier on the basis of their net cost (LCOE - EV - CV + TC); resources with the lowest net cost (including transmission) are allocated the capacity associated with that tier. In the implementation of this method, the transmission cost associated with a tier is applied to all resources that remain in the supply curve in order to determine which resources have the lowest net cost—including transmission—so that the least cost subset may be selected by the Calculator. Once the capacity available in a given tier has been exhausted, the RPS Calculator moves to the next tier of the supply curve and applies the appropriate (higher) cost to all remaining candidate projects.

14. Why does the RPS Calculator currently show that major transmission upgrades are needed to accommodate a small set of commercial projects expected to come online in the near term?

Multiple stakeholders questioned preliminary results shown by the RPS Calculator that indicated that small commercial projects (<100 MW) were triggering major upgrades in specific Super CREZs, and that, in many cases, these projects were expected to come online within the next few years—an unrealistic timeline for the development of a major new transmission project.

It is important to note that the RPS Calculator is not a transmission planning tool in itself. Instead, it is a tool for developing portfolios that serve as *inputs* to a formal transmission planning process. In order to provide inputs that are as plausible and useful as possible for the planning process, the RPS Calculator relies on a reasonable characterization of the cost and availability of existing and new transmission investments. An iterative process between the CAISO's Transmission Planning Process (TPP) and the RPS Calculator provides the model with a substantial amount of information on the availability of existing transmission in a number of parts of the state. However, it is not comprehensive and may not always align with the contracts held by utilities at that time. This leads to instances (as observed by stakeholders) where utilities have CPUC-approved contracts with a resource in a specific area but the CAISO has not indicated that capacity is available on the existing system. Because of the complex and dynamic nature of the planning process as well as the sources and flows of data that inform it, these types of minor inconsistencies are not unexpected.

There are several ways the RPS Calculator could be designed to handle a situation in which a small amount of capacity associated with CPUC-approved contracts appears to "trigger" a major upgrade:

- Exclude the project from the portfolio and assume the major upgrade is not triggered;
- Include the project in the portfolio and assume that it automatically triggers a major upgrade in the transmission system (which the RPS Calculator would thereafter treat as a sunk cost, leading it to be more likely to pick additional resources in that area);
- Include the project in the portfolio but do not assume that it triggers a major upgrade (but allow for the major upgrade to be triggered in the resource ranking and selection algorithm).

The first option could result in "transmission orphans": CPUC-approved projects that are left out of the formal transmission planning process. The second option would be likely to skew the portfolios developed by the RPS Calculator to the CREZ in which that project is located. Because of the disadvantages of the first two approaches, RPS Calculator v.6.0 uses the third approach. The third option enables the RPS Calculator to include CPUC-approved contracts in the portfolio for CAISO's TPP while preventing the inherent limits on transmission information from artificially skewing portfolio development. Generic projects from a region impacted in the manner described above still compete with others for inclusion on an economic basis during the development of the portfolio.

While very small projects are treated in this way, the RPS Calculator does include a threshold beyond which a sufficient amount of CPUC-approved projects will "trigger" a major upgrade. This threshold is currently set at 10% of the capacity of the upgrade (i.e. if the total capacity of CPUC-approved contracts in a CREZ requiring a 1,500 MW upgrade exceeds 150 MW, the model will assume the upgrade is needed and will treat its cost as sunk in the model).

15. **Does the RPS Calculator account for transmission capacity that is freed up by expiring contracts?**

The RPS Calculator v.6.0 does not currently allow projects to compete for transmission freed up by expiring contracts. This will be corrected in v.6.1, in which, when a contract expires, it will compete with generic new projects for the transmission capacity associated with the original contract.

16. **How are transmission capital costs amortized in the calculation of net cost used in resource screening and selection?**

The capital costs for new transmission projects are amortized with an annualization factor of 14.5%, which is intended to reflect both the costs of financing the project and any necessary O&M costs. This assumption is inherited directly from earlier versions of the RPS Calculator but was originally taken from a transmission financing model developed by E3 for the Western Electricity Coordinating Council in 2010. The annualization factor reflects an assumed 40 year lifetime, a capital structure of 52% equity/48% debt, and costs of equity and debt of 11.4% and 6.3%, respectively.

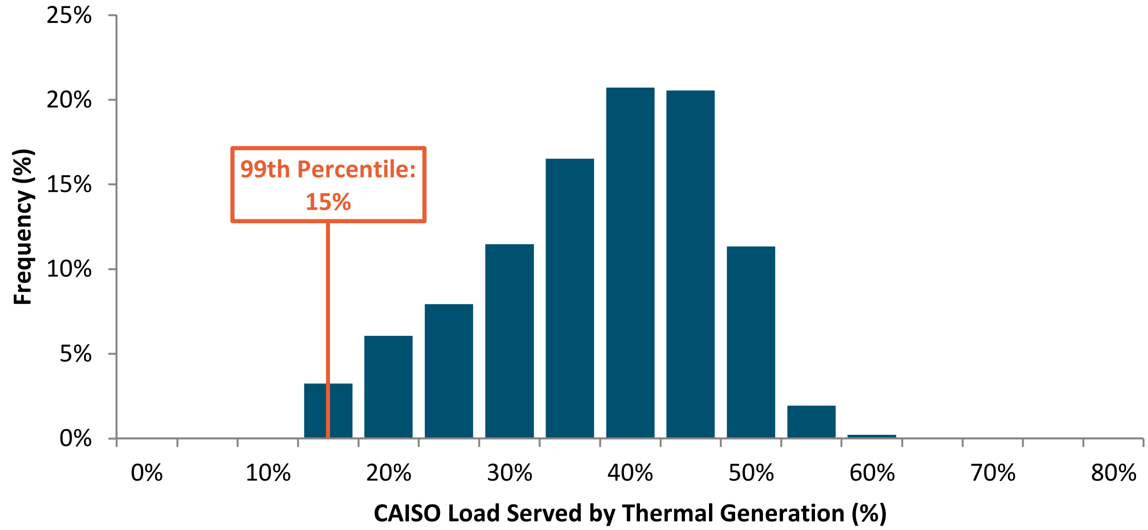
In subsequent updates to the RPS Calculator, E3 will revisit this assumption in v.6.1 to ensure that the cost of capital assumed in the levelization of transmission costs is consistent with those assumed in the derivation of cost-based PPA prices. The Calculator will continue to assume that the costs of new transmission are recovered over a longer term (40 years) than those of new generation resources (20-25 years).

Energy Value

17. **What is the basis for the assumption that 15% of gross load must be met by thermal generation, and how does that compare with other CA studies?**

The constraint that 15% of gross load be met by thermal generation is based on a review of CAISO's actual historical hourly operations from April 20, 2010 through March 31, 2013, as well as rules-of-thumb currently used in production simulation modeling in LTPP and TPP. It is intended to serve as a proxy for the logic that a more detailed operational model would use to establish minimum levels of thermal generation accounting for the need to carry reserves and provide inertia. Figure 1 below shows the distribution of CAISO gross load met by thermal generation throughout this period. From this distribution, the lower 99^{th} percentile is assumed to be the the minimum level of thermal generation in the CAISO balancing authority.

Figure 1. Histogram of CAISO gross load served by thermal generation, April 20, 2010 - March 31, 2013 (CAISO Daily Renewables Watch)



In the CAISO's 2014 Long-Term Procurement Plan (LTPP) study, CAISO applied a 25% regional generation requirement to all balancing authority areas (BAAs) in California, including CAISO.[1] A separate regional generation requirement was also applied to the SDG&E and SCE service areas within CAISO. Generating resources that can meet these constraints include local, controllable generation, such as thermal, nuclear and hydro. The RPS Calculator's simple operational model does not have the technical capability to incorporate such detailed logic; accordingly, the 15% requirement has been derived through observation of actual operations and is intended to serve as a proxy for such detailed constraints.

18. Why does the Calculator use a single hourly shape for each month ('12x24') to characterize load and resource profiles?

The use of a single hourly shape to represent load and renewable performance in each month was based on the need to balance the detail needed to capture declining energy value with the computational limits of Excel. The use of an average hourly shape for each month provides reasonable estimates of the value of energy and frequency of overgeneration for a broad range of portfolios—a major improvement over static functionality of prior versions—without the need for a wide range of costly and time-consuming production simulation studies.

19. Can the resource types used in the energy value calculation be modified to include out-of-state resources?

Yes. This improvement in functionality to capture the diversity of potential out-of-state resources with California loads and renewables is planned for v.6.1; a limited number of resource profiles reflecting out-of-state resources will be added to the Calculator. Stakeholder feedback at the workshop and in

[1] The following document provides a description of the regional generation requirement constraints (available at: http://www.caiso.com/Documents/Aug13_2014_InitialTestimony_ShuchengLiu_Phase1A_LTPP_R13-12-010.pdf)

post-workshop comments guiding the choice of which out-of-state resources to include in the energy value calculation will be considered.

20. How is hydro generation treated in the calculation of energy value & overgeneration?

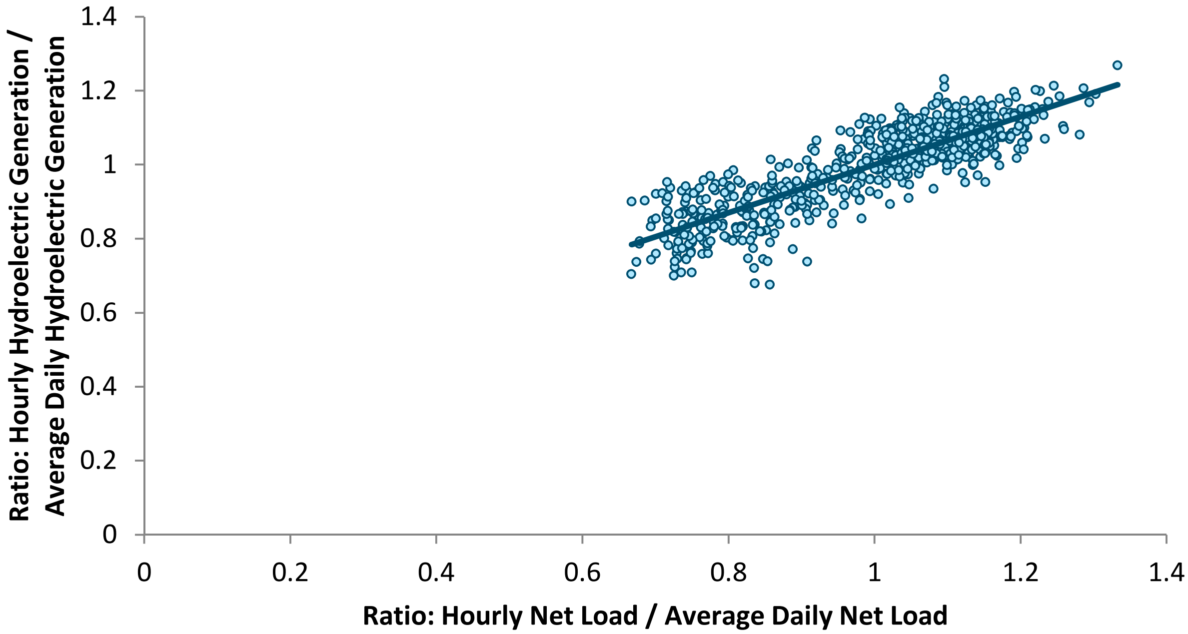
The RPS Calculator relies on a heuristic to model the changing operations of hydroelectric generators as the penetration of renewables on the system increases, which captures the positive correlation between hydro dispatch and net load: the dispatch of hydro in each month is expected to be relatively concentrated during periods of high net load. The method used in the RPS Calculator relies on the following sequence of steps:

- **Specify annual hydro budget:** an annual energy budget is specified for each hydro plant in the CAISO based on historical conditions. The budgets included in v.6.0 are based on a 2003 hydro year.
- **Distribute annual budget to months:** the annual budgets are distributed to the months of the year using a single shape derived from CAISO's Daily Renewable Watch data. For each month, a percentage of the total annual energy is specified.
- **Distribute monthly budget to hours:** for each month's hourly profile, the monthly budget is distributed to the hours using a heuristic based on an observed relationship between hourly net load and hourly hydroelectric dispatch. The relationship is specified through a coefficient *c* that represents the following ratio:

  $$c = \frac{H_{m,h} - H_{m,avg}}{NL_{m,h} - NL_{m,avg}}$$

  Where *H* and *NL* are hydroelectric generation and net load, respectively, and the subscripts denote the appropriate month/hour combination. Figure 2 shows the general relationship captured in this heuristic. In RPS Calculator v.6.0, this coefficient was derived using a limited set of CAISO operational data. As considerably more data is currently available through the CAISO's Daily Renewable Watch, these parameters will be updated in v.6.1 based on the latest available operational data.

Figure 2. Relationship between hydroelectric hourly dispatch and hourly net load, April 2011 (CAISO Daily Renewables Watch).



21. What assumptions are made with respect to the availability of imports to meet load in the energy value calculation?

A number of generators that are located outside of CAISO but contracted to California utilities are included in the energy value calculation. These imports include Palo Verde Nuclear Generating Station, Hoover, Parker, Central Valley Project, and a number of gas-fired resources near the Arizona-California border. The model does not currently capture the possibility of lower-cost unspecified import generation, which could have an impact on the marginal energy value for California resources. This assumption will be re-examined in v.6.1; stakeholder feedback is welcome in post-workshop comments.

Capacity Value

22. What ELCC is assumed for 'baseload' resources?

The ELCC for baseload resources is assumed to be equal to its annual capacity factor (e.g. a baseload resource with a capacity factor of 80% is assigned an ELCC of 80%).

23. What is the basis for the assumption that new out-of-state transmission lines contribute 60% of their capacity to the reserve margin?

The 60 percent assumption is based on the approximate ratio between the quantity of imports CAISO counts in its near-term reliability assessment and the maximum import capability into CAISO. Although import levels are uncertain during the system peak, CAISO expects 10,000 MW of net interchange in its summer supply and demand outlook.[2] The maximum import capability is higher, most recently estimated as 17,486 MW.[3] This assumption reflects the fact that new transmission into the CAISO provides capacity benefits beyond those provided by the resources with which it is directly associated, but that that benefit may not match the full import capability of the transmission line.

24. How will LCR-related procurement decisions be reflected in the RPS Calculator?

The RPS Calculator will defer to the Long-Term Procurement Proceeding with respect to the determination of LCR needs and the resources authorized to fill those local needs. To the extent that LTPP identifies and authorizes new generation capacity – preferred or non-preferred – those resources will be incorporated into the RPS Calculator. The incorporation of this information into the model may impact the development of the portfolio in several ways:

- The added capacity of the resource will impact the CAISO System load-resource balance, affecting the avoided cost of capacity;
- The generation, if renewable, will lower the renewable net short, reducing the amount of generic resources selected by the Calculator; and
- The generation, if renewable, will change the marginal energy & capacity value of additional renewables, which could impact the order of generic resources in the renewable supply curve.

Once need is found and procurement is authorized in LTPP, the results will be incorporated into the RPS Calculator.

25. Can additional resource types be included in the ELCC surface beyond the seven types the Calculator already uses?

The RPS Calculator currently determines ELCC through the use of a multi-dimensional "surface" that represents the contribution of a portfolio of variable resources to system reliability. Currently, six different resource types are included in the surface[4]:

- Solar PV – Distributed
- Solar PV – Utility Scale
- Solar Thermal – No Storage
- Solar Thermal – Storage
- Wind – Coastal
- Wind – Inland

[2] See Table 11 from CAISO's 2012 Summer Assessment (available at: http://www.caiso.com/Documents/Briefing_SummerLoads_ResourcesOperationsPreparednessAssessment-Report-MAR2012.pdf).
[3] Available at: http://www.caiso.com/Documents/ISOMaximumResourceAdequacyImportCapability_Year2014.pdf
[4] In addition to the six resource types in the surface, the RPS Calculator also attributes ELCC to 'Baseload' resources separately (see question 1).

A seventh resource type, representing baseload resources, is also included in the Calculator. In order to capture enough resolution to value the marginal contribution of each technology to system ELCC at differing penetrations and mixes, the surface is characterized by a large number of points. Adding another dimension to the surface would have the impact of multiplying the number of points needed by a factor of five to ten, which would stretch Excel beyond the limits of reasonable computation time. Accordingly, six technologies is the current maximum for the RPS Calculator to handle with respect to ELCC. However, it would be possible to include an additional resource type by replacing one of the existing types.

26. Could the ELCC surface be modified to include out-of-state resources?

Yes, one of the existing resource types could be replaced with a profile representing out-of-state resources such as wind in Wyoming or New Mexico. However, because the out-of-state resources would be developed in conjunction with one or more significant new interstate transmission lines, the incremental capacity value to California loads would need to include the increase in potentially deliverable capacity from the transmission line as well as the renewable resource. The Calculator currently uses a blanket assumption of 60% of nameplate for out-of-state resource/transmission combinations, as described above in response to question 22, to reflect the fact that additional resources could be dispatched in other states to meet peak California needs, even if the renewable resource were not available.

Secondary Benefits

27. Will incorporation of secondary benefits likely impact resource selection and are there forums that are considering these factors?

Resource specific benefits have not been quantified as part of the inputs into the RPS Calculator. Parties will have an opportunity to provide a proposal for including secondary benefits in their post-workshop comments. In addition, parties can address potential secondary benefits in their comments on the LCBF reform effort in R.11-05-005, which will be initiated later in 2015.